SLAC ILC Program & Beam Parameters & Snowmass Planning

Fermilab

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SLAC ILC Program

- Program for FY05/FY06 has six main elements
  - Electron and Positron sources
  - Damping rings
  - Beam Delivery System and Interaction Region
  - Overall design: Beam parameters, Optics, Emittance preservation, Stability/alignment, Instrumentation, Availability, MPS, and Operational issues
  - Conventional construction implications and site development
  - Linac rf technology
    - klystrons, modulators, rf distribution, and possibly couplers
    - Wakefields and cavity optimization
    - Not SC Cavity fabrication

Major Test Facilities

- NLCTA
  - Complete X-band program
  - Create new L-band rf Test Facility
    - Test klystron and modulators for ILC
    - Test normal conducting structures for e+/e- sources
    - Construct coupler test facility
  - Facilities also available in Klystron Test Lab
- End Station A
  - Study Interaction Region issues and instrumentation
  - Mockup of full IR
- ATF-2
  - Test BDS using very low emittance beam
- Utilize other test facilities around the world (TTF, SMTF, STF, ATF)

System Design

- Extensive simulation of sub-systems
  - Balance emittance budgets and specify system tolerances → impact on overall beam parameters
- Consider operational issues
  - Design for availability and work on detailed models → big impact on layouts and configuration but hard to quantify
  - Develop beam tuning algorithms → specify beam instrumentation requirements and layout
  - Consider high-level controls software requirements (applications) for beam control → specify control system requirements
- Develop Machine Protection Scenarios
  - Specify active and sacrificial protection systems
  - Specify beam dumps and beam tuning stations

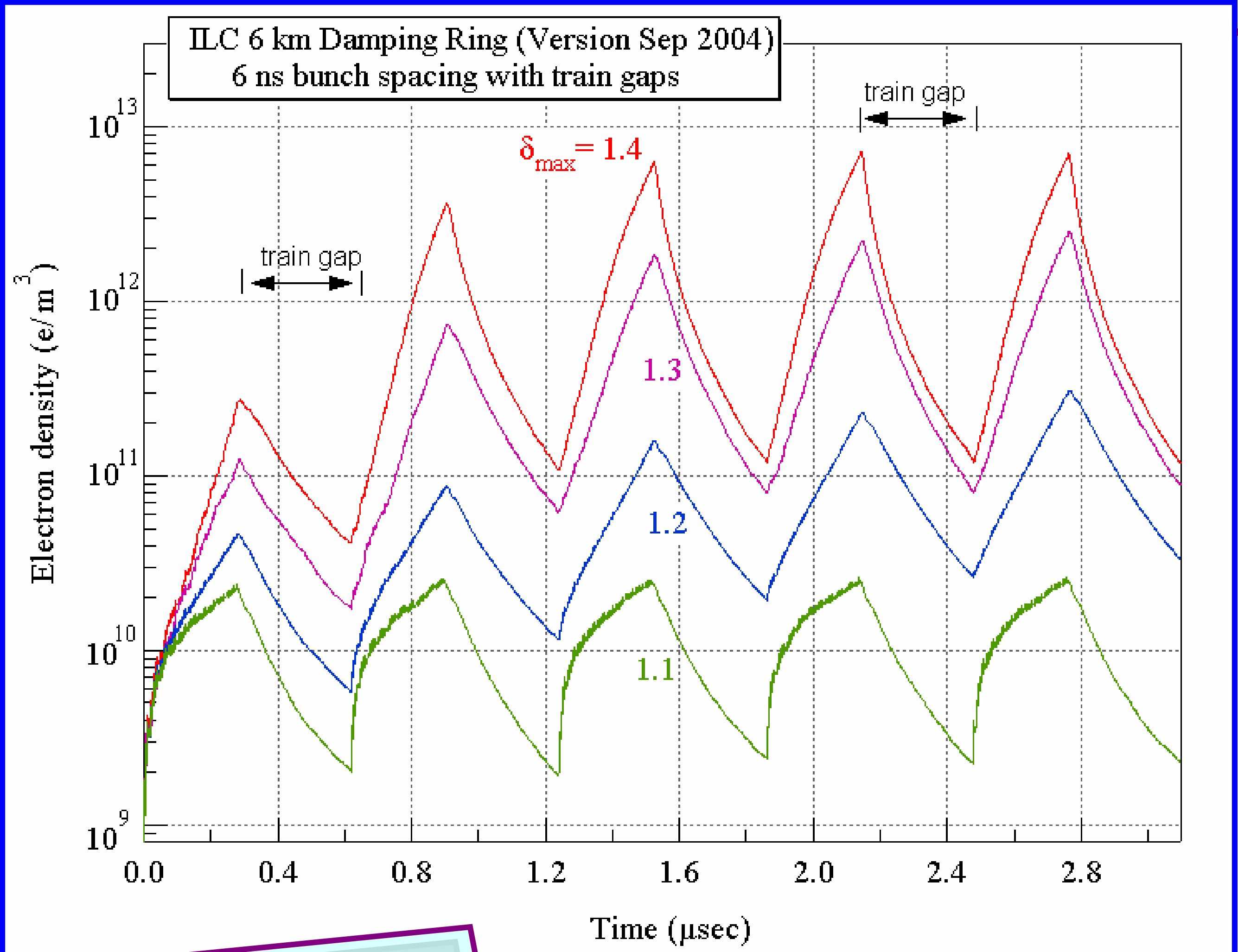
Electron and Positron Source

- Electron source
  - Continuing photocathode development
  - Creating space to begin laser and gun development
  - Need to start design simulations
- Positron source (program with LLNL)
  - Studying target design for undulator, conventional, and Compton sources
    - Radiation damage
    - Thermal shock / beam damage
    - Engineering issues (high rotation speed, remote handling)
  - NC capture structure design and fabrication
  - Capture and optics studies
  - Complete E-166 polarized positron production (spring 2005)

Damping Rings

- Damping ring design (program with LBNL)
  - Optics and tuning studies
  - Collective effects
  - Bunch compressor design
- SEY Studies (program with LBNL)
  - Laboratory measurements in PEL
  - Building three chambers for PEP-II installation to verify solutions
- ATF at KEK
  - Instrumentation (NanoBPM, laser wires, optical anchor)
  - Beam studies (ORM, BBA, FBII, Wiggler)
  - ATF Kicker replacement
  - ATF stripline kicker development
  - FONT/Feather

Electron Cloud Simulations



Electron density in units of e m^3 as a function of time for an arc bend in the 6km DR option assuming a beam pipe radius 22mm and including an antechamber design (full height h=10mm).

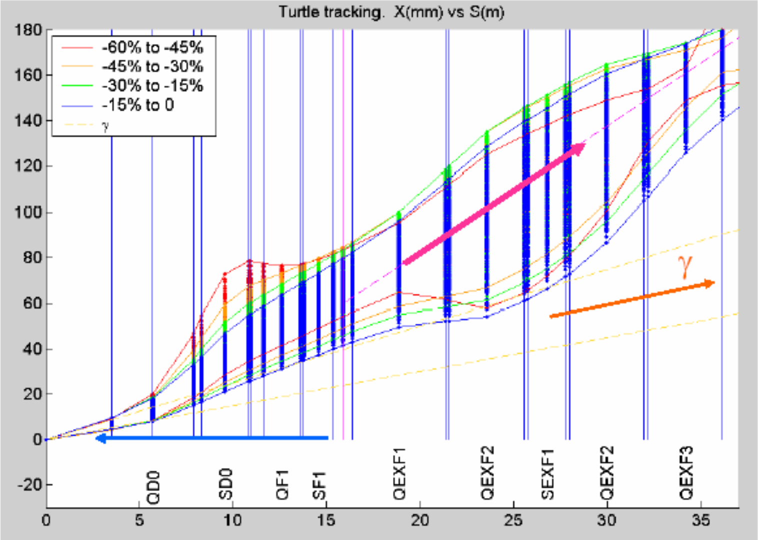
SEY Studies in PEP LER

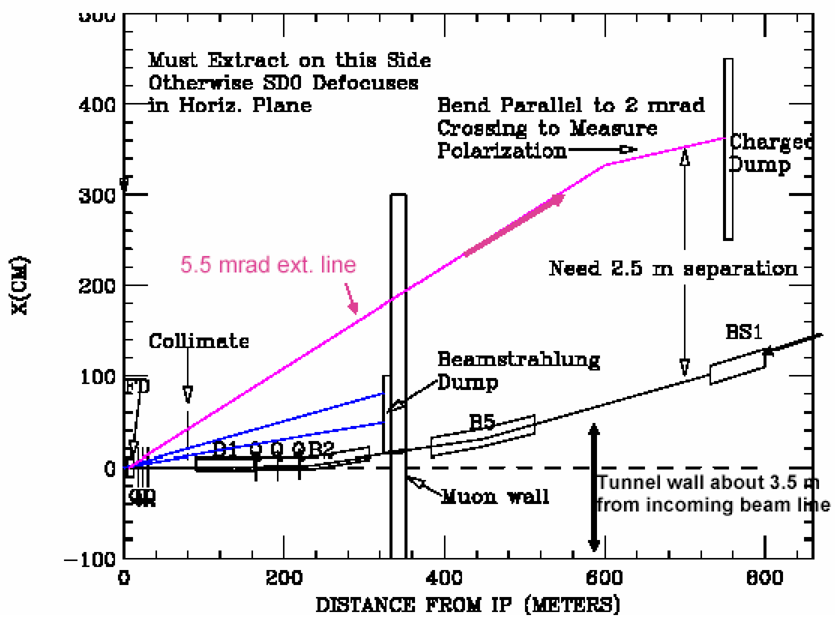
Beam Delivery System

- Optics design and layout (program with UK groups)
  - Study variations of BDS with different crossing angles, collimation systems, L*, etc → understand tradeoffs
- ATF-2 at KEK
  - Demonstration of new FFS using ATF beam
  - Proposal is being assembled – detailed contributions to be defined
- Specialty magnets (program with BNL)
  - SC final quadrupoles are being prototyped at BNL
- ESA Test Facility
  - MDI instrumentation studies, collimator wakefield studies
  - Construct IR mock-up

BDS Design (with UK groups)

- Looking at 20 mrad and near-head-on crossing cases
  - Developed 20 mrad design based on NLC design
  - Developed a 2 mrad design with extraction using specialty magnets





- Comparing collimation system performance with passive system and a consumable system (similar to NLC)
  - Studies are being done at SLAC, UK, and FNAL
  - Initial results show comparable performance

Linac Design

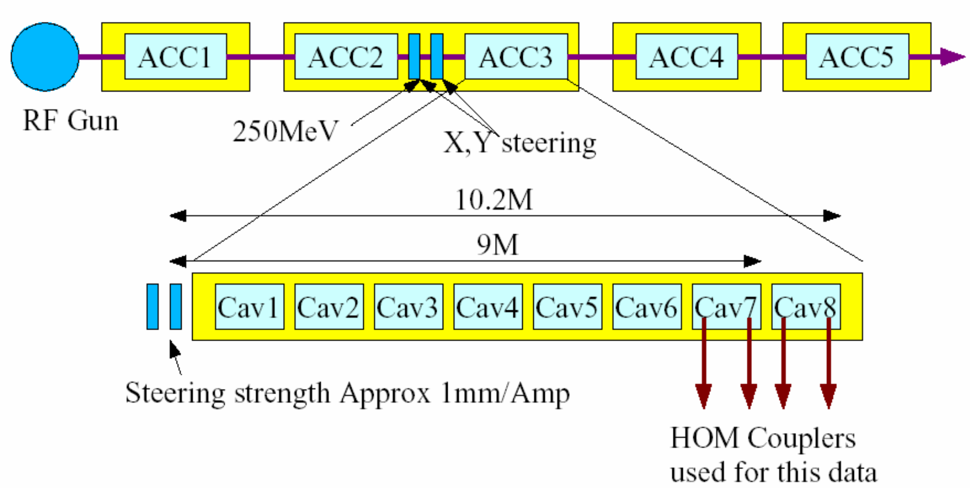
- Quadrupole alignment
  - Use a SC linac quadrupole from DESY to study shunting alignment ability – very important to achieve desired tolerances
  - Continue program for NC quadrupoles
- BPM tests (program with TTF, ATF and LCLS)
  - Develop and test high resolution BPMs
- Laser wire (program at ATF and PETRA3)
  - Work with other groups to test high resolution laser wires
- Cavity diagnostics (program at TTF)
  - Add HOM detectors to SC cavities at TTF to determine beam-cavity location – very important especially for high shunt impedance cavities with small aperture
- Measure vibration due to SC cryogenic equipment
  - Important for conventional layout and BDIR

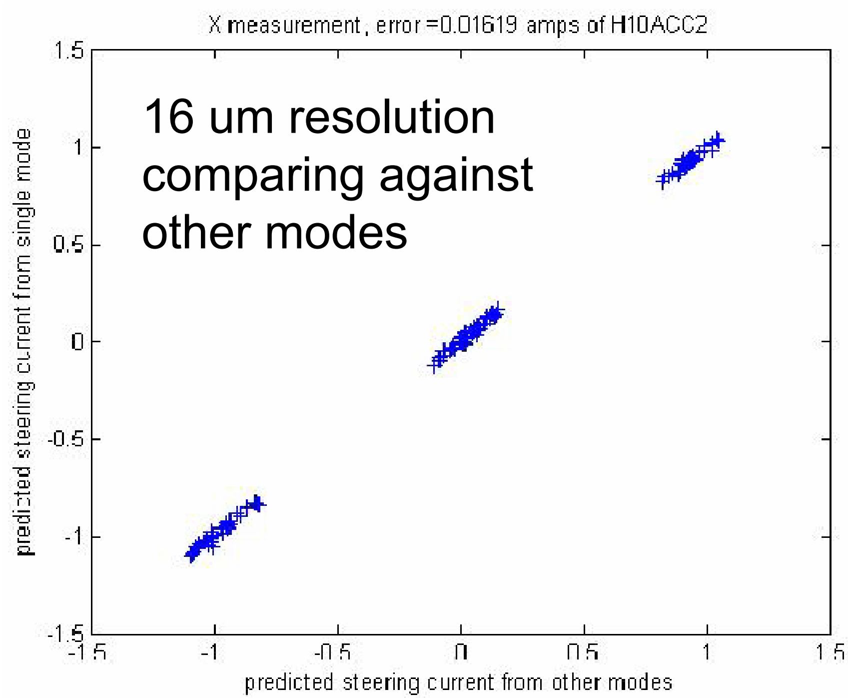
Superconducting Quadrupole

- Beam-based alignment in the TDR assumed use of ‘Dispersion-Free Steering’
  - Method is sensitive to ‘systematic’ errors
  - The technique as proposed was never made operate near expectations in the SLC
  - An implementation at LEP reduced the ‘effectiveness’ by 4~5
- Quadrupole shunting is possibly a more robust technique
  - Main source of systematic error is motion of the magnetic center
- Measure the center motion with a prototype SC quad

Cavity HOM Measurements

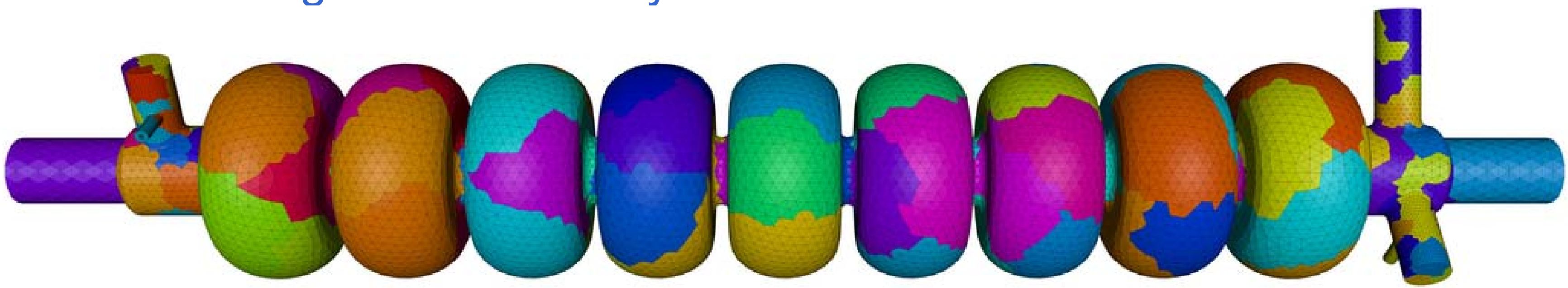
- Understanding HOM signals from TTF
  - Instrumentation used to measure HOMs in the TTF cavities
  - Analysis was complicated because timing system was noisy
  - Seem to achieve resolutions at the 16 micron level
  - Questions about relative alignment of modes
  - Potential to be very useful, especially for LL cavities





Wakefield Calculations

- Extensive 3-D modeling of the TESLA and the new Low-Loss SC cavity wakefields
  - Big computation: 768 processors and requires 300 GB memory
  - Mode rotation may be an important source of jitter
    - Need to understand if this is mostly systematic due to the coupler orientation or due to fabrication errors
    - Huge effect if it is systematic

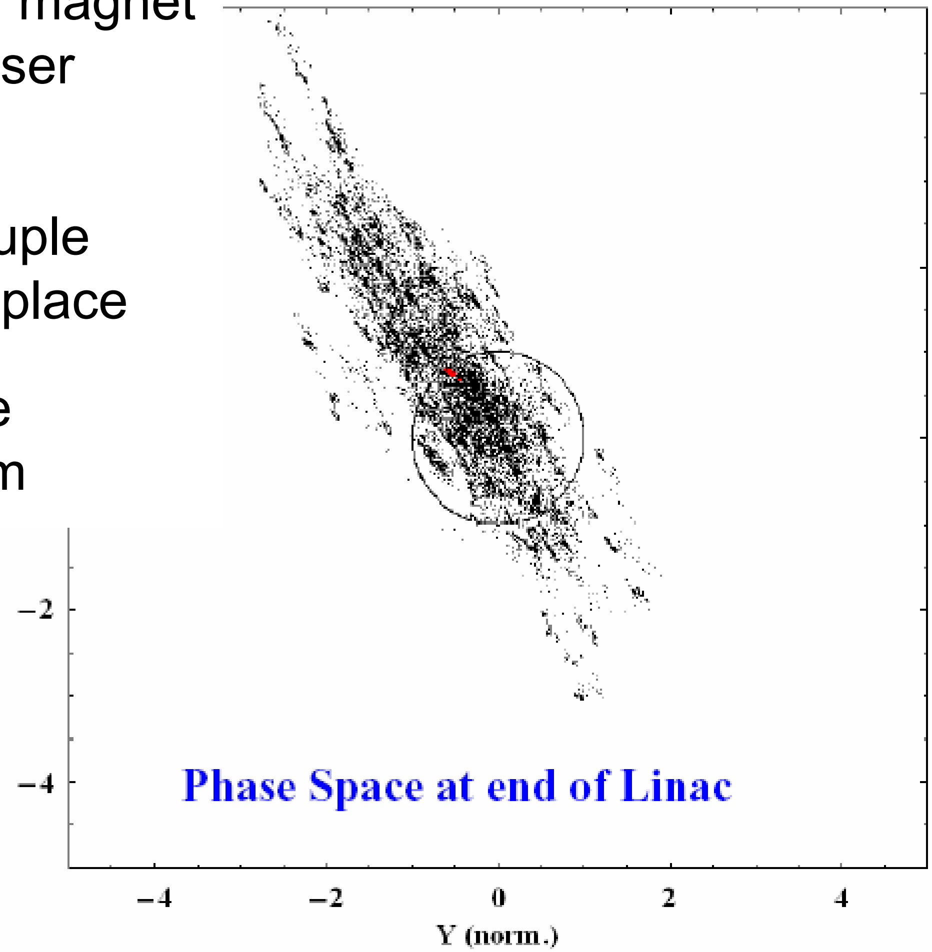


- New Low Loss cavities have lower cryoloads but higher wakes
  - Big impact on design → may make 35 or 40 MV/m possible
  - Need to understand the wakefield implications

$W_\perp$ Mode Rotation

- Separation of the dipole mode frequencies at TTF implies strong X-Y coupling
  - Design of damping ring extract, magnet supports, etc all have much looser tolerances on horizontal jitter
  - Long-range wakefield could couple horizontal jitter into the vertical place
  - Need to understand if these are systematic (couplers) or random (fabrication errors)

Simulation assuming random errors with 400 um initial X motion

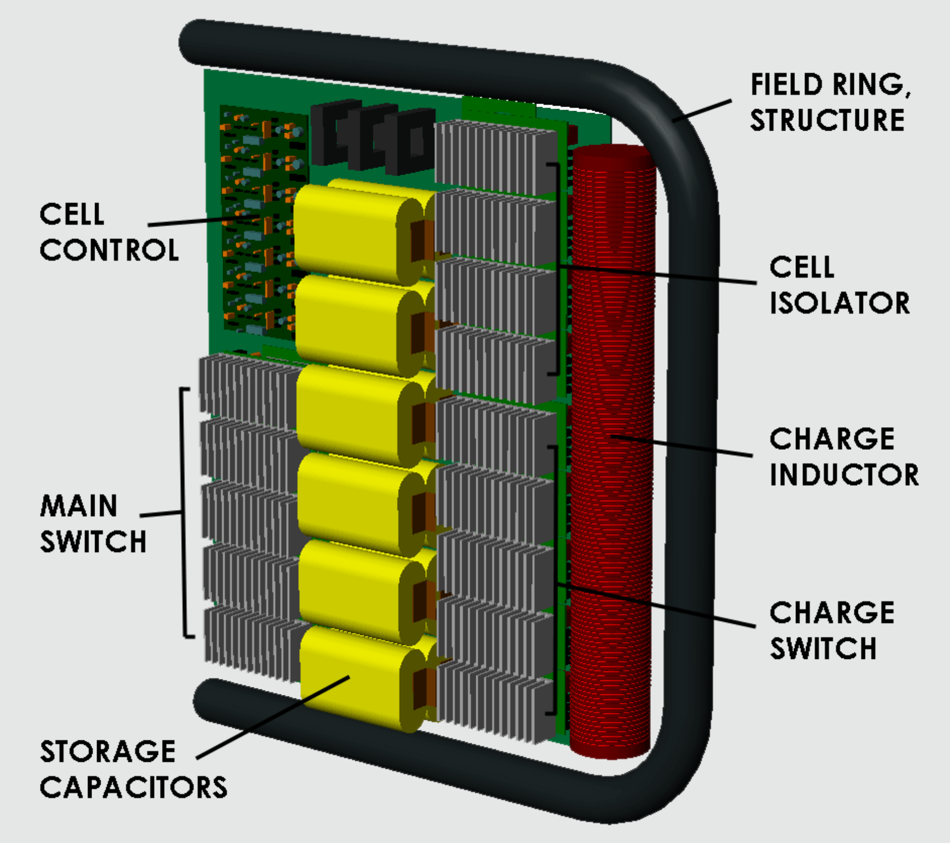


Modulators

- ILC Baseline is essentially FNAL/DESY/PPT modulator
  - Single switch with bouncer circuit and 12:1 transformer
  - Efficiency is pretty good; reliability uncertain; transformer is large and stray fields may impact the damping ring
- SLAC effort is evaluating options
  - Receiving an SNS power converter-modulator which should have good efficiency
  - Building Marx generator style which should provide similar efficiency and 100% availability
  - Building switch for FNAL bouncer-style modulator
  - Working with Diversified Technologies in SBIR program to test another series-switch modulator

Marx Generator Modulator

- Stack of 12 kV units
- Pros
  - Uses emerging technology
  - Modular design for longer MTBF and shorter MTTR
  - No oil; compact unit
  - No magnetic core
  - Finer waveform control
- Cons
  - Uses emerging technology
  - IGBT controls floats at high voltage during the pulse
  - DC power flow must be isolated
  - Timing signals must cross high voltage gradients



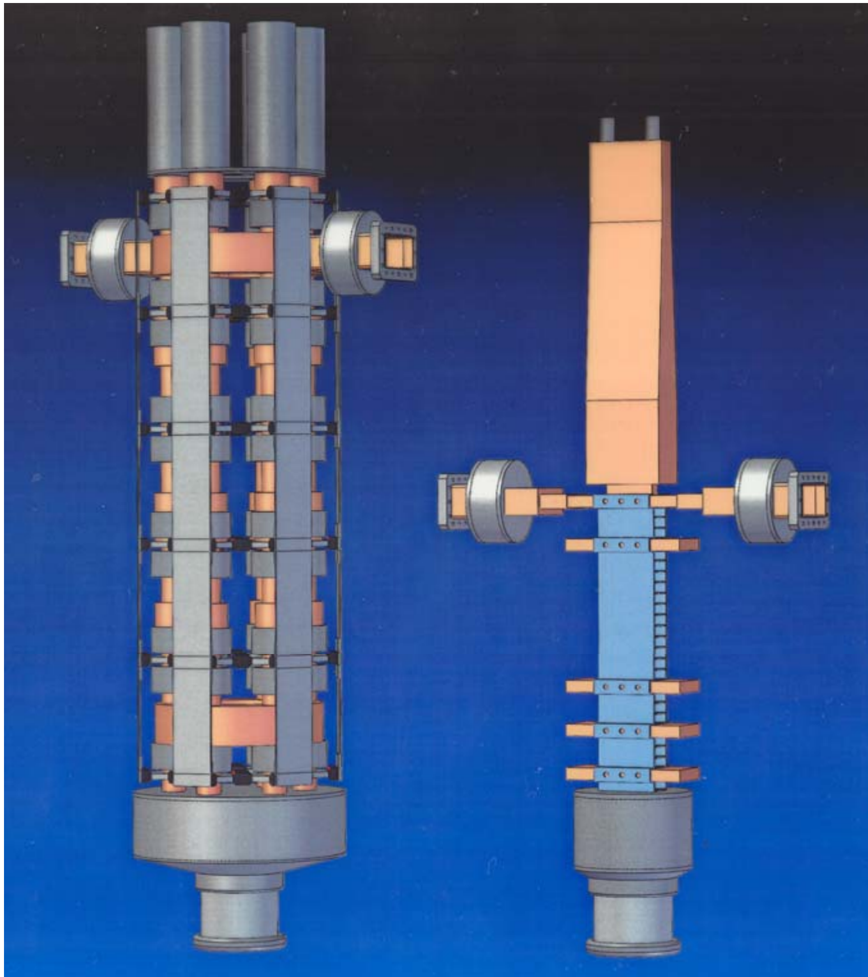
Klystrons

- Three industrial vendors for ‘baseline’ 10MW MBK tubes
  - Still very little real experience with multi-beam klystrons
  - Thales has delivered two refurbished tubes to DESY
  - CPI 10MW tube was accepted by DESY – may come to SLAC later
  - Toshiba 10MW tube is still under test

- Four elements to SLAC program
  - Develop L-band sheet beam klystron
  - Study klystron / modulator options
    - More conservative 5MW tube or lower power PPM tubes
    - Decide which (if any) of these to pursue further
  - Buy L-band rf power at SLAC (needed for experience and other elements of program)
  - Possibly work with DESY and CPI on CPI 10 MW tube

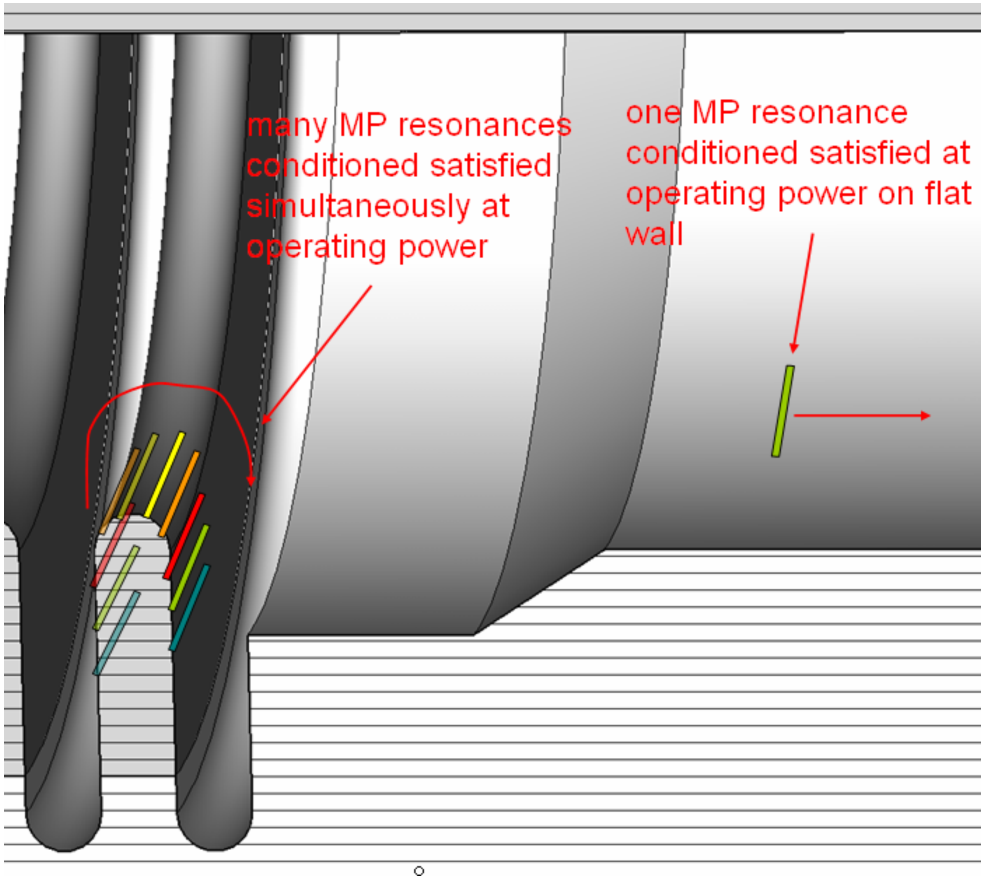
Sheet Beam Klystron

- Exploring a sheet beam klystron as an alternate to the MBK tubes → significant cost reduction
  - High efficiency design using flat beams instead of 6 beamlets
  - Smaller with simpler focusing, cavities, and cathodes
  - Intrinsically 3-D design however the tools exist these days
  - No experience with sheet beam tubes
    - Building a W-band tube using external funding



Other RF Topics

- Large number of ideas and requests for help
  - Constructing an SC 'materials' test facility
  - Studying TTF3 coupler designs and limitations
  - Looking at new approaches for the rf distribution that would reduce the number of components



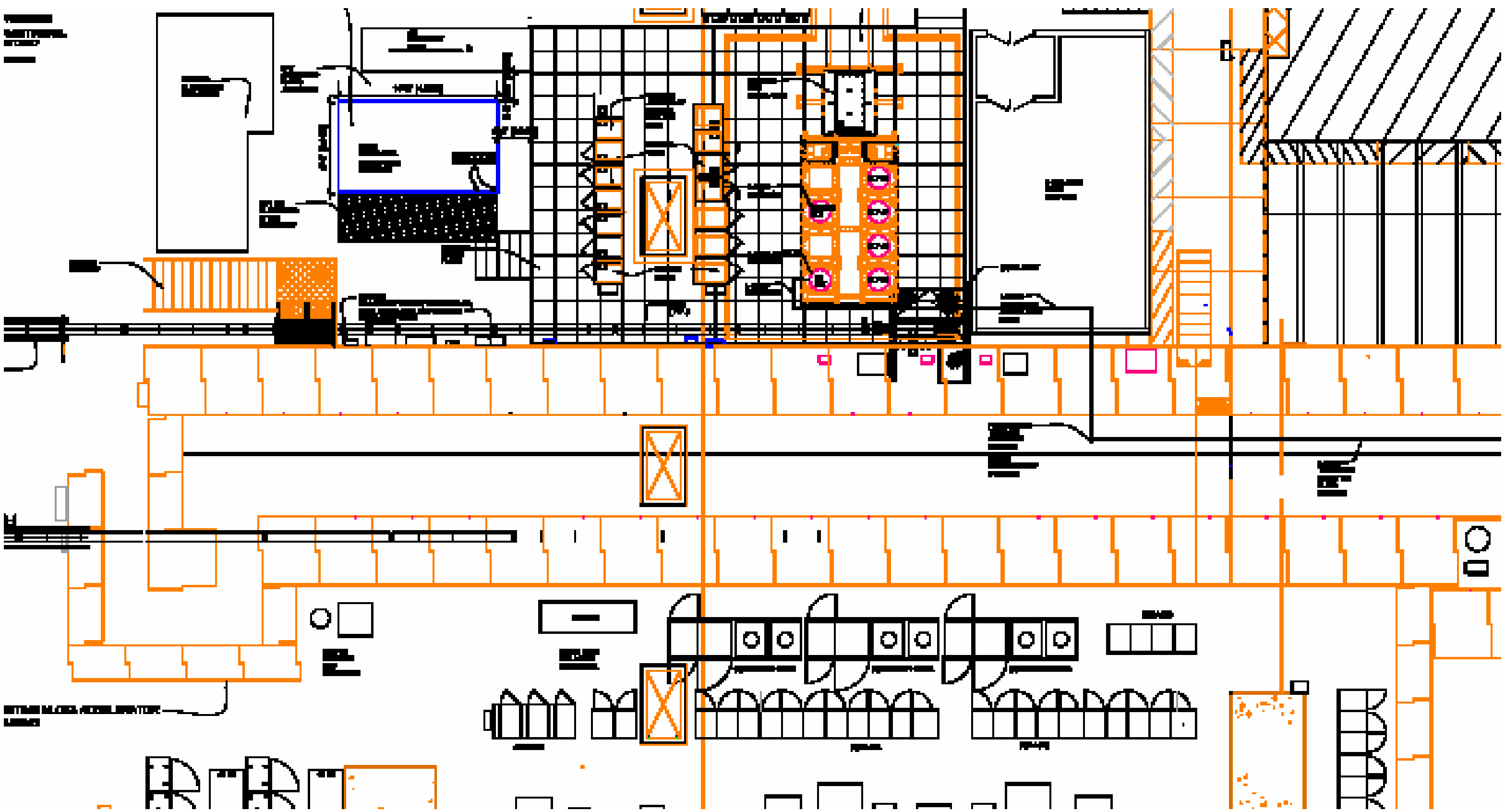
  - Considering a 'coupler' test facility in ESB which would model a loaded SC cavity using normal conducting technology
  - Working on concepts for new circulators

End Station B Program

- Complete X-band program at NLCTA
  - Test CERN structure and other gradient studies
  - Test active switching technology
  - Expect to decommission 8-pac modulator this year
- Start construction of an L-band test facility → next slides
- Create facility to construct prototype collimators for the LHC
  - Adaptation of NLC consumable collimator technology to allow the LHC to reach design luminosity
- Support E-163 laser acceleration experiment

ESB L-Band Test Facility

- Build L-band test facility in ESB
  - Test modulators and klystrons
  - Test NC accelerator structures and couplers



ESB L-Band Test Facility

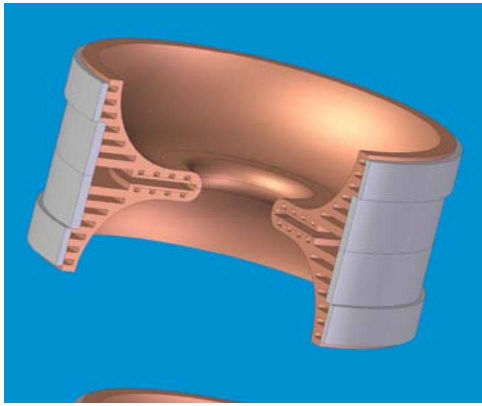
- Modulator will be delivered from SNS this summer
- Scrounging klystron parts from SDI/Anthrax/etc programs
- Buying 5 MW tube from Thales (1 year delivery)

SNS Modulator

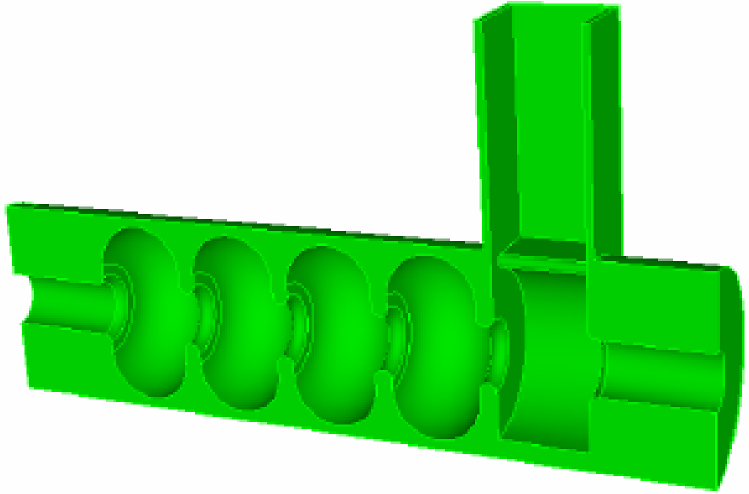
FNAL 2095 Klystron

Normal Conducting Structure

- Proposed Structure Design for Positron Source with Mechanical Simplicity, effective cooling and Low Pulsed Heating:
    - Capture sections: Simple π mode short SW sections
    - Pre-Acceleration: High phase advance TW structures
- Working Progress:
    - Preliminary design for both SW and TW structures
    - Electrical and cooling design for a 5-cell SW structure
    - Ready to start mechanical design



Cell Number	5
Aperture 2a	60 mm
Disk thickness	18 mm
Q	29700
Shunt impedance r	34.3 MΩ/m
RF Pd at 15 MV/m	3.6 kW/cell
Particle Pd	6.2 kW/cell
ΔT (Average/Transient) °C	3.1 / 0.8

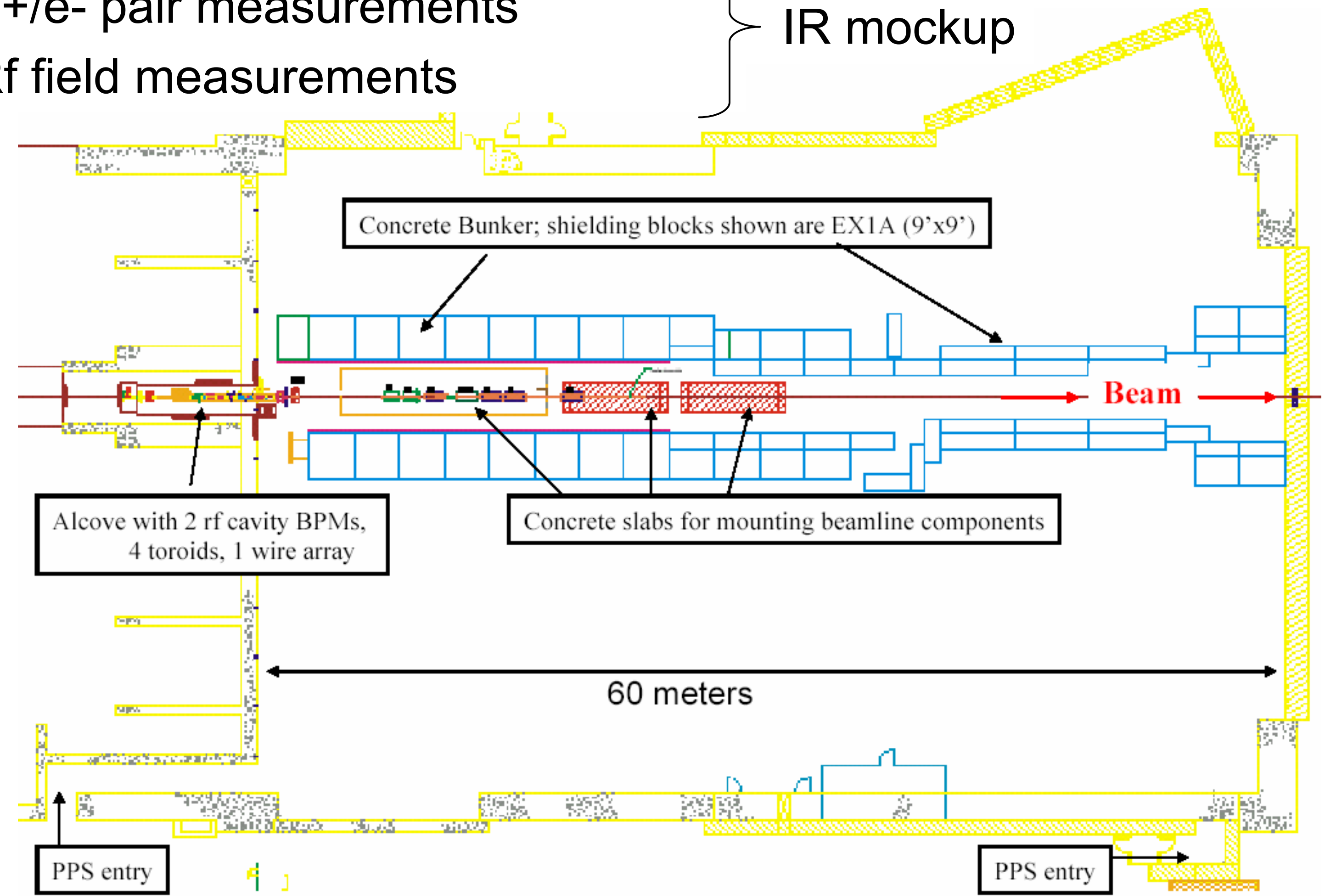


International Linear Collider at Stanford Linear Accelerator Center

End Station A

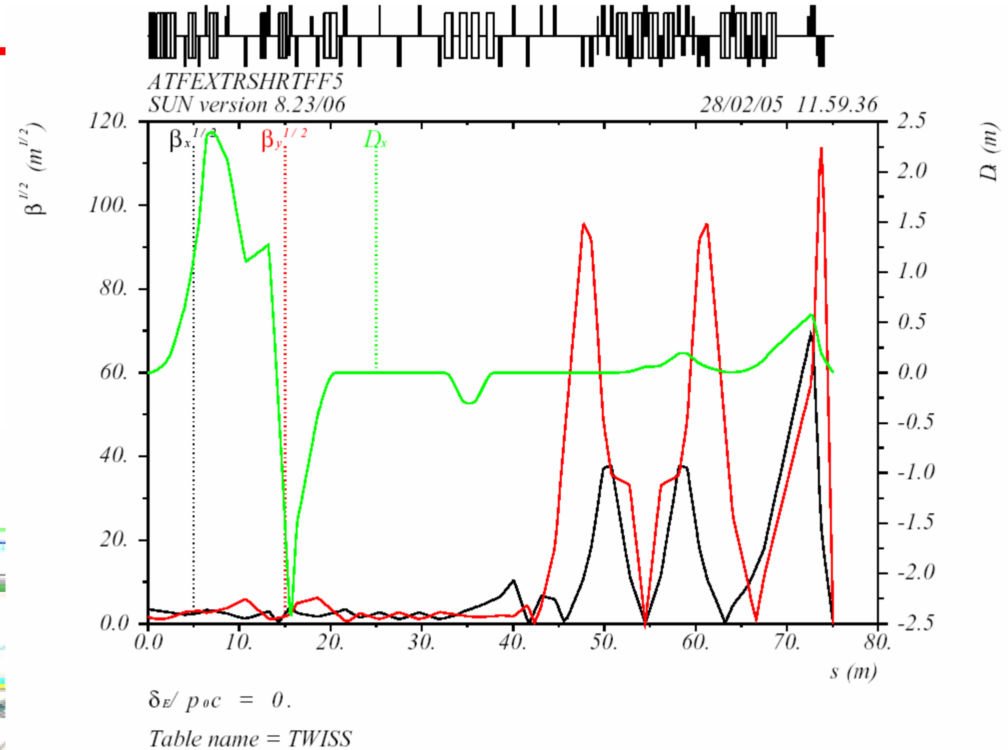
- Significant international interest
  - Energy measurement techniques
  - E+/e- pair measurements
  - Rf field measurements

IR mockup

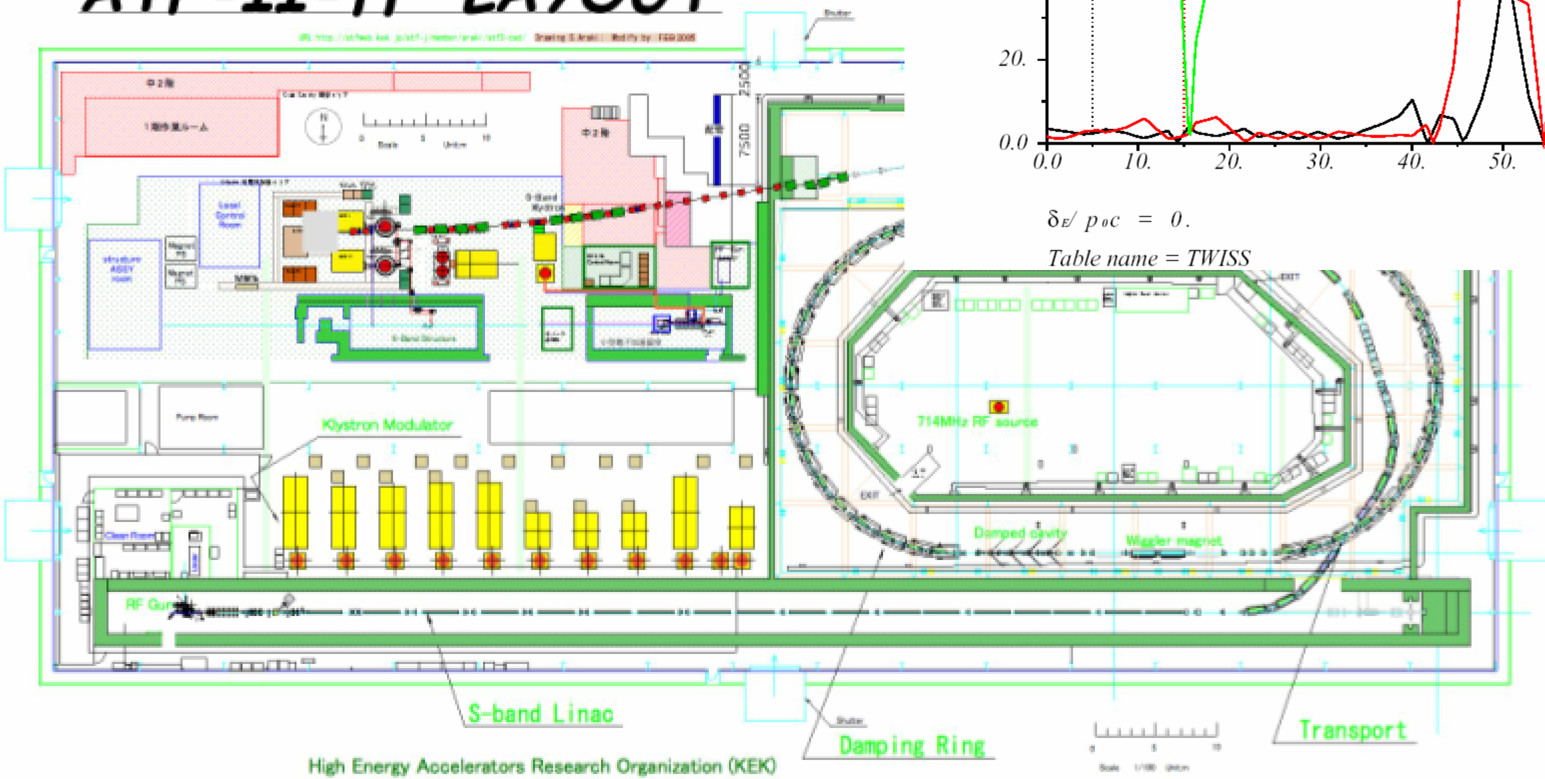


ATF-2 at KEK

- ATF-2 would be BDS test
  - Follow-on to FFTB
  - New FFS optics
  - Operational issues



ATF-II-ff LAYOUT



Reasons to develop the ATF-2

- Many reasons to develop the ATF-2
  - Luminosity issues will be extremely challenging in the LC
    - Likely more challenging than achieving the beam energy
  - Complete FFTB studies
    - FFTB never demonstrated routine operation of FFS
    - Need to implement full feedback control and optimization
    - Operate with ILC like bunch train and demonstrate IP feedback
    - Operate with stable low emittance beam from ATF DR
  - Provide demonstration and experience concurrent with ILC construction
    - FFTB experience will be over 15 years old
    - Train new generation of physicists
    - Provide a visible test facility for project reviewers and sponsors

ILC Budget

- FY05 DOE budget is 22.7 M$
  - 16.2 M$ to SLAC

Source	M$
DOE ILC Program	+15.2
DOE SLAC Operations	+0.5
US-Japan Program	+0.85
Xfers to LLNL, LBNL, BNL	-1.9
SLAC indirect overhead	-3.01
SLAC Direct funds	**11.6**
SLAC Labor	8.4
SLAC M&S / Shop	3.2

- FY06 DOE budget is 25 M$
  - Distribution is unknown
  - Developing a detailed plan for FY06 based on 16.2 M$
  - Working with Robin Staffin and Barry Barish to clarify this

Summary

- Last few months have been 'interesting'
  - Technology choice was difficult
  - Major accident
  - Budget shortfall
- Very exciting strong program addressing most of the design issues
  - SLAC program addresses 14 of the 15 "R2" items identified by the 2003 TRC report as well as many additional problems
    - FY05 Program description will be posted on the ILC web site
    - FY06 Program description is being put together
- Program is focused on overall accelerator design issues as well as a few technology development concepts

TESLA TDR Parameters

peak luminosity

3×10^{34}

parameter space

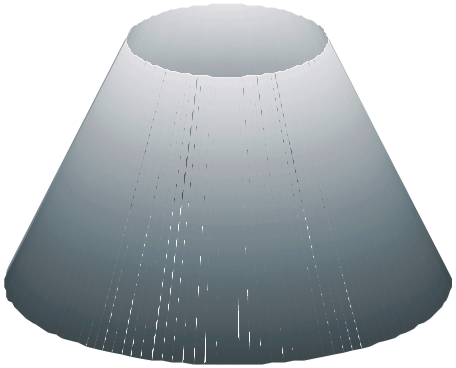
- 3×10^{34} $cm^{-2}s^{-1}$ peak achievable
- Possible due to very high beam-beam disruption (D_y)
- Well into kink-instability regime (unstable)
- Little head room to play with

Slides from Nick Walker, LCWS 2005

ILC Parameters

peak luminosity

2×10^{34}



parameter space

- Define baseline at relaxed goal of 2×10^{34} cm^{-2}s^{-1}
  - consistent with WWS 500fb^{-1} in first 4 years
- Now have several possible parameter sets (parameter ‘plane’)
- Operational flexibility
- Sub-system experts to evaluate trade-offs between relevant parameters

Slides from Nick Walker, LCWS 2005

International Linear Collider
at Stanford Linear Accelerator Center

ILC Parameters

Suggested ILC Beam Parameter Range

by Tor Raubenheimer (SLAC)

available from:
http://www-project.slac.stanford.edu/ilc/
http://ilc.desy.de
http://...

parameters discussion forum:

http://www-project.slac.stanford.edu/ilc/discussion/Default.htm

This document intended to provoke <u>your</u> feedback and comment!

Slides from Nick Walker, LCWS 2005

Parameter Plane

		nom	low N	lrg Y	low P
N	$\times 10^{10}$	2	1	2	2
n_b		2820	5640	2820	1330
$\varepsilon_{x,y}$	μm, nm	9.6, 40	10, 30	12, 80	10, 35
$\beta_{x,y}$	cm, mm	2, 0.4	1.2, 0.2	1, 0.4	1, 0.2
$\sigma_{x,y}$	nm	543, 5.7	495, 3.5	495, 8	452, 3.8
D_y		18.5	10	28.6	27
δ_{BS}	%	2.2	1.8	2.4	5.7
σ_z	μm	300	150	500	200
P_{beam}	MW	11	11	11	5.3
L	$\times 10^{34}$	2	2	2	2

Range of parameters design to achieve 2×10^{34}

Slides from Nick Walker, LCWS 2005

Pushing the Luminosity Envelope

		nom	low N	lrg Y	low P	High L
N	$\times 10^{10}$	2	1	2	2	2
n_b		2820	5640	2820	1330	2820
$\varepsilon_{x,y}$	μm, nm	9.6, 40	10, 30	12, 80	10, 35	10, 30
$\beta_{x,y}$	cm, mm	2, 0.4	1.2, 0.2	1, 0.4	1, 0.2	1, 0.2
$\sigma_{x,y}$	nm	543, 5.7	495, 3.5	495, 8	452, 3.8	452, 3.5
D_y		18.5	10	28.6	27	22
δ_{BS}	%	2.2	1.8	2.4	5.7	7
σ_z	μm	300	150	500	200	150
P_{beam}	MW	11	11	11	5.3	11
L	$\times 10^{34}$	2	2	2	2	4.9!

Slides from Nick Walker, LCWS 2005

Comments on Snowmass

- Goal
  - Establish >80% of Baseline Configuration
  - Path to resolving remaining issues by end of 2005
  - R&D topics to support beyond the Baseline Configuration
  - Documented Baseline Configuration and R&D plan by end of year
- Concern
  - Many European and Asian colleagues cannot attend for 2 full weeks
- Result
  - First 5 days 2nd ILC Workshop → decide on configuration
  - 2nd week detail the config, start work on remaining issues, detail the R&D topics
- Important to register now!
- Please plan to come for the full two weeks – lots of important issues to work on during the second week